The Impact of I-80: Air and Noise Pollution In Aquatic Park

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Introduction

Aquatic Park lies on the western edge of the City of Berkeley between University and Ashby avenues. The Park is bounded on the west by Interstate 80 and on the east by the Southern Pacific Railway. The Park is Berkeley's largest municipal park and is used by joggers, bikers, ultimate frisbee players and various species of birds. The proximity of the Park to the freeway means that the noise levels are quite high due to the traffic. The large volume of cars also produces concerns about the level of airborne pollutants inside the Park.

Recently the City was involved in negotiations with the Department of Transportation (CalTrans) over the possibility of incorporating improvements to the Park into the I-80 expansion project. The opposition of Berkeley residents to the expansion of I-80 led to the City voting down the proposed freeway agreement, and thus ended any chance of obtaining help from CalTrans for improving the Park.

With the idea in mind of improving conditions and boosting use of the Park, the City has embarked on a revision of its Parks Master Plan. This paper was in conjunction with the Parks and Marina Department and focused on the issues of noise and air quality that are not included in the Parks Master Plan. These, along with other issues, were taken up by the 1989 Environmental Sciences Senior Seminar in order to aid the City in finding the best recommendations for the future of Aquatic Park. This paper will focus on quantifying both noise levels and carbon monoxide (CO) concentrations in an effort to determine the physical characteristics of air pollution and noise pollution in the Park, and how the micro scale climate of the Park may affect plans for its renovation.

Past Studies

There has been no previous study of air quality or noise pollution inside Aquatic Park. The City did formulate noise contours contained in the City of Berkeley Master Plan of 1977 (Berkeley, 1977), but no measurements were taken inside the Park. The issue of air quality along the I-80 corridor was presented in the 1983 CalTrans environmental impact statement of the effects of widening the freeway, but Aquatic Park was not a study site (CalTrans, 1983).

Background

Air Pollution

In the field of air quality the relative severity of air pollution problems are determined by comparing the concentrations of the pollutant in the area in question to the standard determined by the state. In the case of carbon monoxide (CO), there are two standards of relevance, the primary and secondary standards. There are two standards for CO because the severity of the problem is dependent on time; therefore a one-hour limit and an eight-hour limit have been set. The state of California sets the one-hour standard at 20 ppm (parts per million) and the eight-hour standard at 9.0 ppm. The federal government sets standards for CO also, with a one-hour standard of 35 ppm and the eight-hour at 9.3 ppm (BAAQMD, 1987).

In terms of urban air quality there are many pollutants of concern, with carbon monoxide being only one of them. The other large air borne contaminants are oxides of nitrogen (NO_x) particulate matter, ozone (O_3), oxides of sulfur (SO) and hydrogen sulfide (H_2S) (BAAQMD, 1987). The automobile plays a large role at some point in the formation of all of these pollutants (in the case of H_2S, a large quantity of it comes from refineries). Since the automobile is such a large player in the formation and distribution of these pollutants, it became necessary for the state to be able to predict the concentrations of these pollutants on a reliable basis. In the 1970's CalTrans and the Environmental Protection Agency (EPA) began to develop models for predicting the air pollution consequences of building projects involving automobiles (freeways, interchanges etc.) and by the mid-70's CalTrans had introduced the CALINE series of computer models. The CALINE series went through four versions of which the latest, CALINE4, was produced in 1984 (Benson and Pinkerman, 1984). The CALINE programs were meant to allow the user to predict the concentrations of pollutants near roadways. The CALINE4 program can be used to predict the concentrations of nitrogen oxides, particulates and carbon monoxide at or near a roadway. Also in 1984 CalTrans came out with the OBSMAX program which is used to determine the maximum observed concentration of CO in a given location (Benson, 1984). These two models have since been supplemented with models like EMFAC7, which takes into account traffic volume, fuel use, hot and cold start data and uses certain pre-programmed assumptions to estimate the Composite Emission Factor. This is the amount of pollution an average car would give off per mile for the pollutant in question. These computer models are the primary ones currently in use in the estimation of the impacts that new freeways will have on air quality. They do not seem to have been used much in regards to projects that were proposed before 1984, and specifically they were not used in the formulation of the air quality impact analysis used in the 1983 I-80 Expansion Project Environmental Impact Statement (EIS) (CalTrans, 1983).

Sound

The important concepts in the consideration of noise pollution are Level Equivalence (L_{EQ}), Level Day and Night Dose (L_{DN}), and Peak. The concept of Peak is the easiest; it is simply the loudest event to take place in a given sampling period. There is no real standard with which to compare different Peaks; one is simply larger or smaller than another. However, a useful bench mark is that a jet plane flying at 1000 ft generates a Peak of over 120 Decibels (dB). While there is no standard for Peak, it is a useful parameter to study as some research shows that the most commonly occurring Peak is associated with the level of annoyance people in a given area will register (May, 1978; Rylander et al., 1986). Dose is defined by the Occupational Safety and Health Administration (OSHA) to be 90 dB for 8 hours. In other words, a person exposed to 90 dB for 8 hours would have received a 100% Dose. Dose is useful for comparing different exposures over varying time periods. Level Equivalence is the time weighted average level a person is exposed to. L_{EQ} is used to express the amount of sound energy a person is exposed to in terms of an equivalent level. L_{EQ} smooths out all of the various peaks and valleys in an exposure and makes them uniform (sums them). It is most useful in comparing levels amongst different places that may have different noise pollution sources or distributions. Lastly is the concept of Level Day and Night (L_{DN}), which is the same as L_{EQ} except that it is averaged over a 24-hour period (Quest, Inc., 1987). Many municipalities (including Berkeley) measure noise levels in this way as it is the best way to determine the overall impact on a resident who lives in a certain locality (Berkeley, 1977).

The State of California Office of Planning and Research (OPR) has provided guidelines and mandated that each city in California has to incorporate a section dealing with noise issues in its Master Plan (this is referred to as a "sound element"). In the state's guidelines there are divisions as to the recommended allowable noise level based on what the area in question is used for. For the case of Aquatic Park, the designations of interest are for a Neighborhood

Park and for a Water Recreation Park. The federal Guidelines closely mirror the state's and once again depend on the land use and discretion of local authorities. (Federal Interagency Committee on Urban Noise, 1980).

The City of Berkeley chose to adopt the state's guidelines and did create noise contours for the City in 1977. The City's Master Plan also makes reference to a 1972 Department of Housing and Urban Development recommendation that 80 dB be the goal for hearing conservation (Berkeley, 1977). However, the Master Plan does not address the question of where certain segments of the City lie in terms of their land use planning designations and therefore leaves unanswered the question as to the specific noise levels that the City would deem tolerable. Since there is so much emphasis placed by the State guidelines on what the land use designation is, the maximum levels that would be acceptable have really been left up to the City.

Methodology

The air pollution modeling used in this study was accomplished by using CALINE4 and EMFAC7, which were run on an IBM AT. The versions of the models that were used were provided in the California Air Resources Board's (CARB) Air Quality Two package.

User Description: EMFAC7PC

The EMFAC7PC model uses four main parameters to calculate the Composite Emission Factor used in CALINE4. These parameters must be supplied (or at least confirmed) by the user. The first is Ambient Temperature, the second is Fleet Mix, the third is Fuel Use, and the fourth is Hot and Cold Start Percentages. Hot and Cold Start Percentages describe the number of vehicles traveling through the modeled section of road after having just been started. Some of these vehicles will have been driven one trip, turned off, restarted and driven through the segment (Hot Start Mode). Other vehicles will have just been started after having been idle for a number of hours before being driven through the segment (Cold Start Mode). This parameter is impossible to determine experimentally and must be estimated. The Fuel Use parameter is the percentage of vehicles in a certain category that burn a certain type of fuel. The fuel types under consideration are leaded gasoline, unleaded gasoline, and diesel fuel. These parameters are also estimated, but more reliable data exist than for Hot and Cold Start Percentages, and the model comes equipped with assumptions based on the year modeled. It is up to the user to confirm or change the Fuel Mix before running the program. The Fleet Mix parameter can be either measured or estimated. The number of vehicles traveling through the segment in question is divided into five categories: Automobiles, Motorcycles, Heavy Trucks, Medium Trucks and Light Trucks. Once these parameters have been entered into the program, the program can be run to produce the Composite Emission Factor for use in CALINE4. The Composite Emission Factor is velocity dependent, so the user must select the velocity in question, or run the computer for the full range of velocities, from 0 to 55 mph in 5 mph increments (CARB, 1989).

User Description: CALINE4

When using CALINE4, the user usually wishes to model a segment of roadway (parking lots, intersections, and interchanges are also possible) to determine the air pollutant concentrations near the road. Unless the segment in question has very similar characteristics along its whole length, the segment is divided into "Links", each of which is considered separately by the program, and then are summed to find a cumulative impact. The reason for dividing a study area into Links is to take into account differing topographies, structural characteristics and traffic patterns. The CALINE4 model requires a number of inputs depending on the pollutant in question and how complicated the Links in question are. For the runs done in this paper, the required parameters were: Wind Speed, Wind Bearing, Stability Class, Vertical Mixing Height, Standard Deviation of Wind Bearing, Surface Roughness, Ambient Concentration, Ambient Temperature, Link Coordinates, Receptor Coordinates, Vehicles per Hour and Composite Emission Factor. The segment of Interstate 80 along Aquatic Park was divided into two Links: Eastbound and Westbound. The Links had the parameters of Wind Speed, Wind Bearing, Stability Class, Vertical Mixing Height, Standard Deviation of Wind Bearing, Surface Roughness, Deposition Velocity, Settling Velocity, Ambient Concentration, and Ambient Temperature in common. Stability Class, Vertical Mixing Height, Standard Deviation of Wind Bearing, Surface Roughness, Deposition Velocity, Settling Velocity and Ambient Concentration are all parameters that were estimated from data in the CARB manual, and other literature sources (BAAQMD, 1987; CalTrans, 1983). The parameters of Link Coordinates and Receptor Coordinates are arbitrary and were set up to simulate a receptor 300 meters from the source. The Deposition Velocity and Settling Velocity parameters for carbon monoxide are both zero (CARB, 1989). The remaining parameters (Wind Speed, Wind Bearing, Ambient Temperature, and Vehicles per Hour) were measured on site, as well as an estimate of average speed, which was used in choosing the Composite Emission Factor for each Link (CARB,1989).

Air Pollution

The EMFAC7 input parameters, Fleet Mix and Ambient Temperature, were measured on site (Figure 1). Eastbound traffic was estimated from site number one, and westbound traffic was taken from site number two. The traffic compositions used were measured by counting vehicles in one of the five categories (Automobiles, Motorcycles, Light Trucks, Medium Trucks, and Heavy Trucks) for one minute at either the morning or evening rush hour. Then the figures obtained were multiplied by sixty to obtain an hourly estimate. This was repeated for both the eastbound and westbound lanes of I-80 on five occasions and then averaged to obtain the traffic volumes. The traffic volumes were then reduced to the percentage of each category in the hourly rate, and the numbers obtained were used as the Fleet Mix. (Table 1).

Link	Automobiles	Motorcycles	H. Trucks	M. Trucks	L. Trucks
East	78.7	0.9	3.0	1.2	16.2
West	77.4	1.1	2.2	3.2	16.1

Table 1. Vehicle Composition by Link (%)

Data for the number of vehicles operating in the cold and hot start modes were taken from examples in the Air Quality Two Handbook and are not specific to the site (CARB, 1989). The percentage used for Heavy Trucks was divided between the diesel and the gasoline powered categories used in the model. The Fuel Mix data for the 1990 year seemed high, so the 1985 year data was substituted for use in forming the Composite Emission Factor (see Appendix A).

The values for the CALINE4 input parameters that both the eastbound and westbound links had in common appear in Table 2. The value used in each Link for Vehicles per Hour was obtained in the manner outlined above in the Emfac7 procedure, and the vehicle speeds were estimated at the sites in Figure 1. For the eastbound lane the Vehicle per Hour value was found to be 7620 Veh./ hr at a speed of 10 mph. This meant that a Composite Emission Factor of 57.3 g CO/mile was used for the East Link. For the West Link the Vehicle per Hour value was 5580 Veh./hr at a speed of 20 mph, which corresponded to a 32.58 g CO/ mile Emission Factor.

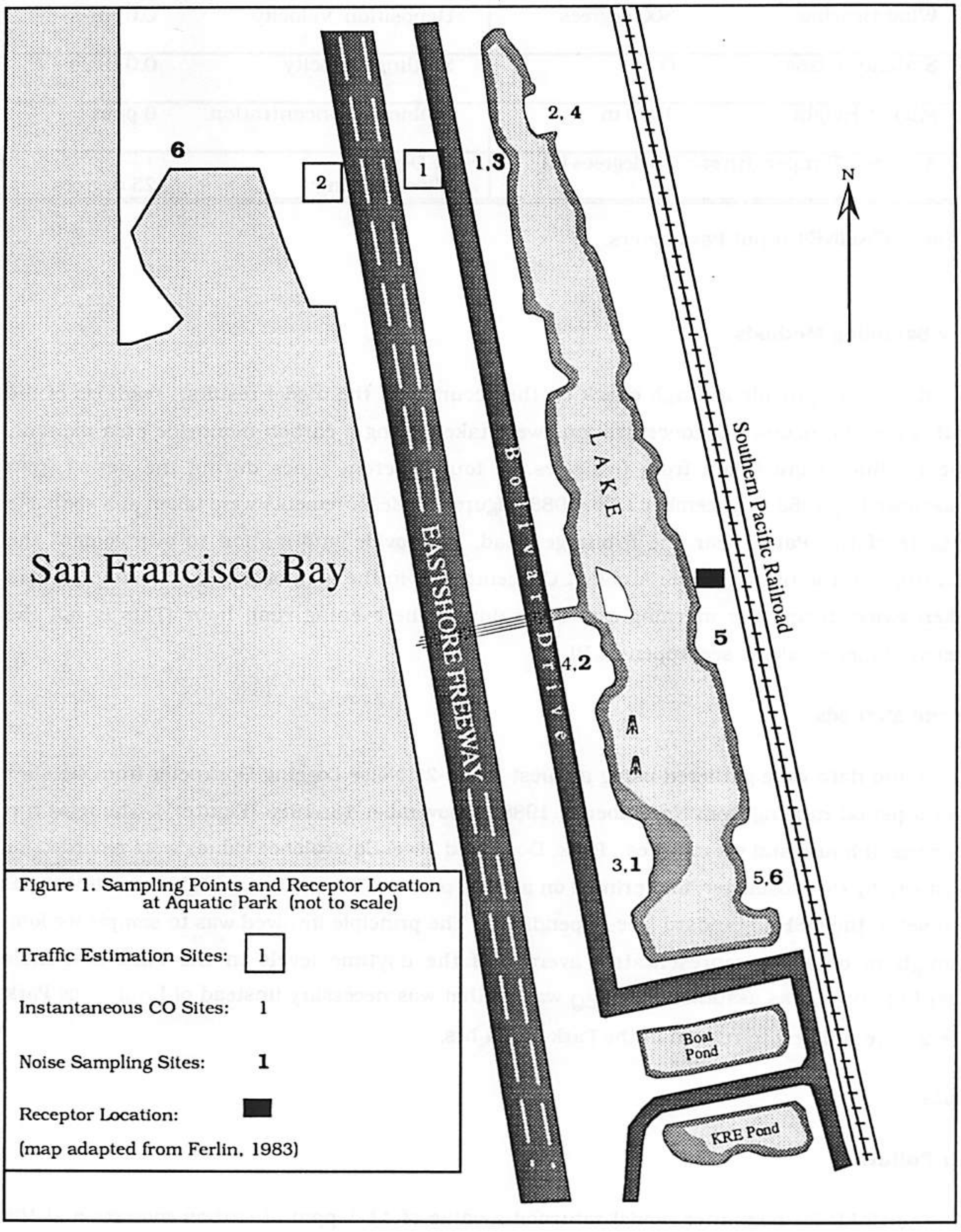

Figure 1. Sampling Points and Receptor Location at Aquatic Park (not to scale)

Wind Speed:	0.5 m/s	Surface Roughness:	127 cm
Wind Bearing:	300 degrees	Deposition Velocity:	0.0 cm/s
Stability Class:	G	Settling Velocity:	0.0 cm/s
Mixing Height:	1000 m	Ambient Concentration:	6 ppm
Ambient Temperature:	15 degrees (C)	St.Dev. of Wind Bearing:	25 degrees

Table 2. CALINE4 Input Parameters.

Site Sampling Methods

In order to provide a rough check on the accuracy of the model results, readings of the Park's instantaneous CO concentrations were taken using a carbon monoxide area monitor. The readings were taken from five sites, at four different times during the period from December 1st, 1988 to December 13th, 1988 (Figure 1). Measurements were taken at a sixth site outside of the Park, near the Frontage Road, to provide information to supplement the literature on the nature of the Ambient Concentration in the area of the Park. Samples were taken twice during the morning and twice during the evening rush hour (This is not the preferred methodology: see Appendix B).

Sound Methods

Sound data were gathered using a Quest Inc M-27 Noise Logging Dosimeter from six sites over a period ranging from November 5, 1988 to November 13, 1988 (Figure 1). The total run time was 9 hours and six minutes. Peak, Dose, and Level Equivalence values were recorded for each site by the Dosimeter, and printed on an IBM printer. The meter was calibrated to 110 dB and set to the OSHA standard (see Appendix C). The principle involved was to sample for long enough to obtain a representative average of the daytime levels in the Park and their distribution. It was assumed that L_{EQ} was all that was necessary (instead of L_{DN}) since Park users were unlikely to remain in the Park for 24 hrs.

Data

Air Pollution

The CALINE4 computer model returned a value of 11.1 ppm of carbon monoxide at the receptor location 300 meters inside the Park (see Appendix D).

The results of the instantaneous sampling were a high value of 14 ppm of carbon monoxide at site # 4 during the morning rush hour, and a low of 3 ppm at sites 5 and 3 during the evening rush hour (Table 3). The first two samples (#1 and #2 in Table 3) took place in the morning, and the second two (#3 and #4 in Table 3) were taken in the evening.

Site:	1	2	3	4	5	6
Sample # 1	11	8	10	14	7	-
Sample # 2	7	5	5	5.5	6	6
Sample #3	4	4	4	4	3	-
Sample #4	6	6	3	5.5	3	-

Table 3. Distribution of Instantaneous Readings by Site (ppm)

It is important to note that while these data were not obtained through the preferred methodology, they do point to trends in the Park. The most noticeable trend is toward decreasing concentrations on the eastern edge of the Park (away from the freeway) and toward the southern end.

Sound

The Peak and L_{EQ} values that were recorded appear in Table 4. The highest recorded L_{EQ} value was 77.5 dB and the lowest was 69.9 dB. The time weighted average value for the Park's eastern side was 72.0 dB, for the Park's western side the average was 75.2 dB, and the Park's overall average was 74.1 dB. The highest recorded Peak came from site number one and was 125.2 dB. The Peak values from each site are shown in Figure 2. The highest recorded Dose value was 17.41%.

Sites	1	2	3	4	5	6
L_{EQ}	77.5	74.7	75	72.8	69.9	70.5

Table 4. Level Equivalence Data by Site (dB)

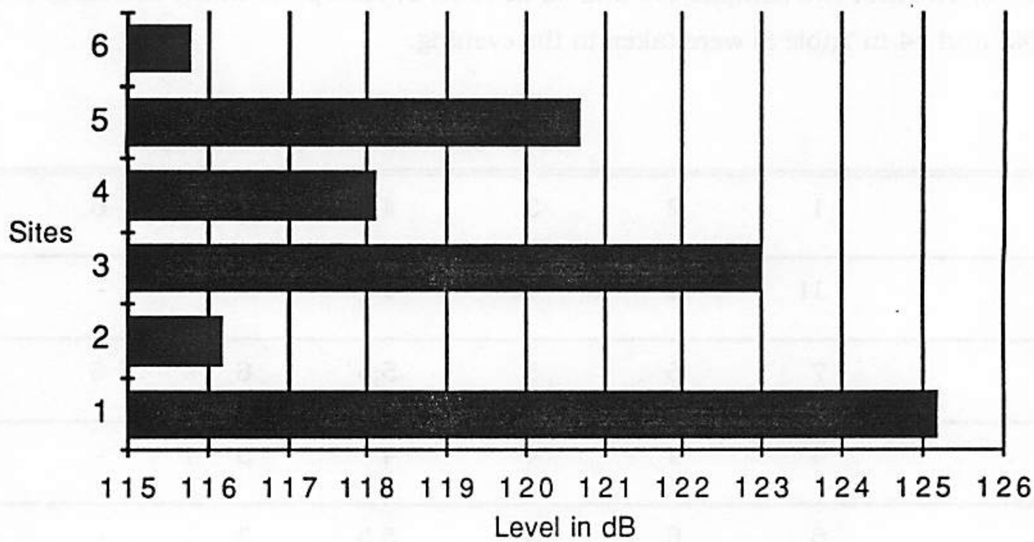

Figure 2. Peak Values by Site (dB)

Discussion

Air Pollution

The CALINE4 model provides an estimate of the amount of CO that would be observed by a receptor located inside Aquatic Park (Figure 1). The model results depend mostly on traffic volume and speed. There is also a substantial role played by temperature in keeping the carbon monoxide close to the ground (colder temperatures usually lead to higher concentrations). Thus the worst case analysis for carbon monoxide will change if the traffic volume changes, or if the average speed of the traffic increases or decreases. The model results of 11.1 ppm are not close to the one-hour state standard of 20 ppm, but clearly the potential exists for the traffic volume to produce a value above the eight-hour standard of 9 ppm if the conditions should arise. This is unlikely to occur at the present moment because the congested conditions tested usually last for around two hours in the morning and evening, and do not exist over an eight-hour period.

The results of this study bear particularly on the I-80 expansion project. The assertion by CalTrans that the High Occupancy Vehicle (HOV) lanes will decrease congestion (CalTrans, 1983) is tenuous at best. The most successful HOV programs (Washington, D.C.'s I-66 for example) work well not because they are a faster way to work (HOV's are usually only faster on paper) but because of the implementation of a preferred parking program for HOV van pools. The addition of HOV lanes and the omission of the rest of the program, such as the parking, leaves a certain amount of doubt as to whether the lanes will substantially decrease traffic volume as CalTrans hopes. If the plan fails, and traffic volume increases in the Aquatic Park region, or on days when the Bay Bridge is backed up (nearly every day), the extra lanes could have an adverse air quality effect on the Aquatic Park region by increasing the traffic density without increasing the mixing zone. In other words, a wider freeway, accommodating more cars in the same width increases the possibility that the freeway will produce levels above the 20 ppm one hour standard inside the Park. It should also be noted that this expansion takes place in an era of continued growth in the I-80 corridor and inaction on the National Fuel Efficiency Standards, two factors which may increase the ambient levels of CO, making the I-80 corridor a more substantial air quality risk in the future.

Sound

The fact that the highest Dose recorded was only 17.41% shows that the noise levels in Aquatic Park are nowhere near the OSHA standard and are also well below the hearing conservation goal. It is therefore unlikely that anyone will lose their hearing by being in the Park over any length of time. However, the OSHA standard is for indoor occupational exposures and is of little help in determining the effects of noise levels on the land use planning issues surrounding the Park. The L_{EQ} data are far more helpful in this respect. The noise levels that were recorded in the Park fall into a gap in the state's recommendations. The average level for the Park (74.1 dB) falls into the "Clearly Unacceptable" range for a Neighborhood Park and the "Normally Unacceptable" range for a Water Recreation Park. While it is up to the City to choose which of the state's two designations it wishes to apply to Aquatic Park, the noise levels are still in the unacceptable range. One other important point is that the values obtained for the L_{EQ} levels have their highest values closest to the freeway, and that the distance across the lagoon caused a noticeable difference in L_{EQ}.

The Peak values may also be of significance in determining the public's reaction to noise levels in the Park. Three of the recorded Peak values 125.2 dB, 123 dB, and 120.7 dB are in the range generated by an aircraft flyover (120 dB). It is important to note that these Peak values do not seem to follow the geographical distribution of the L_{EQ} values. This may be because the trains that pass the Park on its eastern edge contributed to the distribution of the Peaks.

Recommendations

Clearly the most serious problem inside Aquatic Park is noise pollution. The noise levels that are encountered every day inside the Park make it imperative for the City to attempt to reduce them if it wishes to make the Park more attractive to Berkeley residents. However, it does not appear that the City will have the means, either political or monetary, to build a sound wall. Fortunately, this is not the only avenue to reducing noise levels in the Park. Currently most of the land area on the western edge of the Park is covered by pavement from the now unused Bolivar Drive. The most expedient, and environmentally pleasing way to reduce noise levels would be to remove the pavement and replace it with a suitable stand of trees and bushes. Enough room could still be left on the lake side of Bolivar Drive for an exercise/nature trail along the water. The greatest density of plant life would not eliminate the noise in the Park, but it would provide a noticeable reduction, and at least hide the freeway from view, which would have a beneficial effect on the setting. Also, any gains in noise reductions on the western edge of the Park would be more pronounced on the eastern edge, and perhaps all the way into the avenues behind the Park (Figure 3).

The elimination of Bolivar Drive impacts one major use group, the water skiers that use the Park. If the road were replaced by trees, there would be no access to their launch point. This brings up the issue of Aquatic Park's designation in relation to the state's guidelines. The City must decide if the Park is to be a Neighborhood Park, or a Water Recreation Park. If it is termed a Neighborhood Park, then probably the power boats should be eliminated as a use. If it is a Water Recreation Park, then in order to lower noise levels a different launch point should be found. Fortunately, it appears that the boats could be launched from the boat house on the lake's northeastern corner. However, the power boats are also sources of noise pollution, so any gains made against the freeway could be undermined by their continued presence.

The air quality issues are beyond the City's reach except in one aspect. The Environmental Impact Statement for the I-80 Corridor study has two major flaws; one, it was very brief in its consideration of air pollution: "The combination of prevailing westerly winds throughout the year with a moderate average low temperature during the winter months help keep the I-80 corridor relatively free of pollutants" (CalTrans, 1983). Clearly there was not a significant attempt to address air quality issues in the EIS, nor was there any consideration of micro scale impacts, such as those affecting Aquatic Park. The main problem with the EIS is that it was done before CALINE4 and OBSMAX were published and came into use (the EIS dates from 1983). The Final draft of the EIS does engage in some prediction of carbon monoxide, but leaves out particulates and nitrogen oxides. Both of these pollutants have different characteristics than

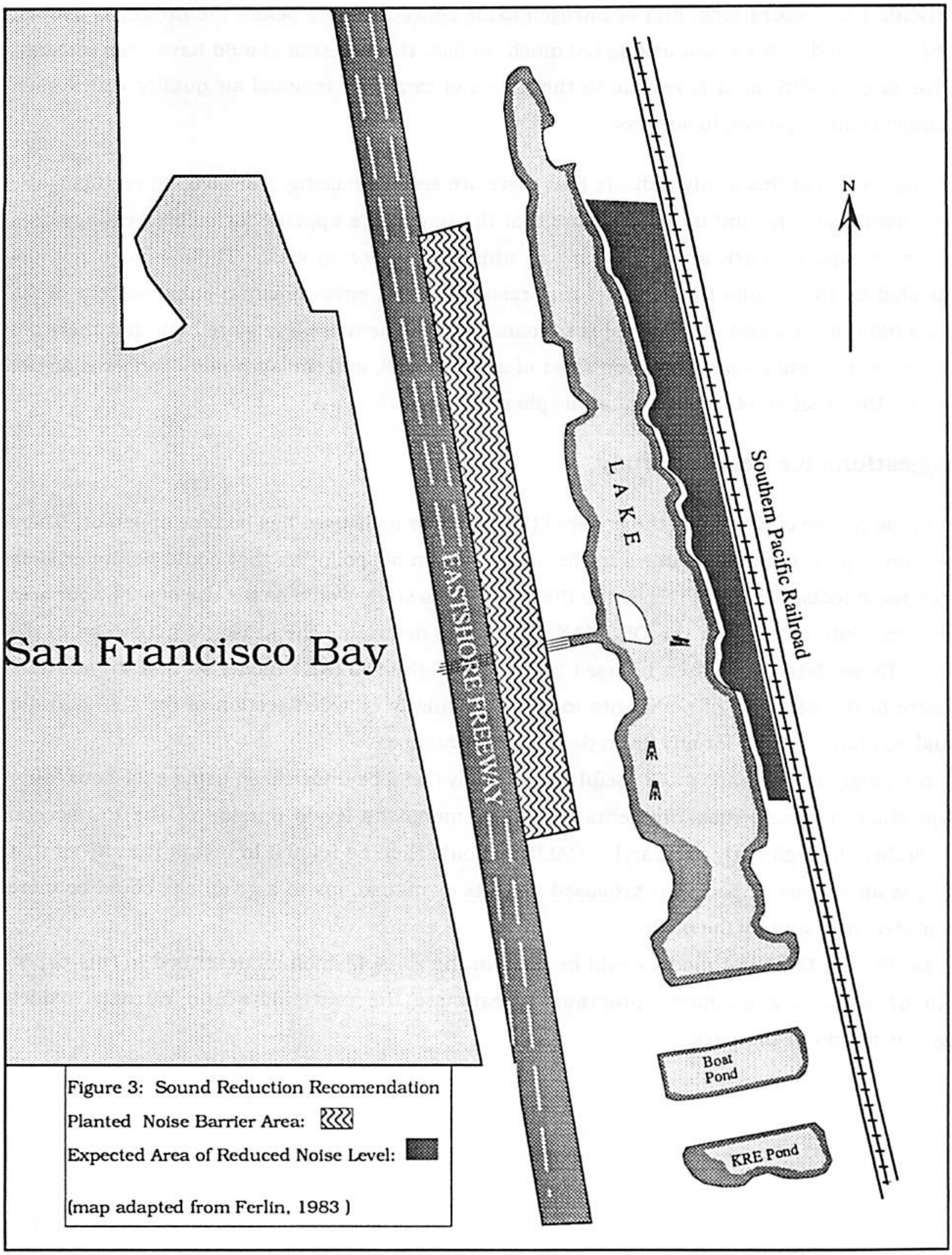

Figure 3: Sound Reduction Recomendation

Planted Noise Barrier Area:

Expected Area of Reduced Noise Level:

(map adapted from Ferlin, 1983)

CO and are certainly worth studying. The City should attempt to require an evaluation of particulate concentrations, and of nitrogen oxide concentrations before the project is allowed to be completed. This is not asking too much. In fact, this material should have been included in the original EIS, as it is central to the issues of local and regional air quality which such documents are supposed to address.

The results of this study indicate that there are severe challenges involved in rectifying the noise level problems and in making sure that the Bay Area's appetite for better freeways does not make Aquatic Park an unpleasant or unhealthy place to visit. There is also nothing indicated by the results that suggest that renovation and environmental enhancement of the Park's habitat area and user appeal is unmanageable. The noise levels are high, but there are avenues of reduction open that stop short of a sound wall, and the air quality concerns do not prohibit the creation of a pleasant atmosphere in the Park.

Suggestions for Further Study

In the course of this study the power of the computer tools used has become apparent. There are many applications for studies in the area of urban air pollution that could be undertaken using these tools. The most relevant to the goals of this study would be the use of a 24-hour area tester in conjunction with the OBSMAX program to determine the seasonal maximum in the Park. These data could then be used to "calibrate" the CALINE4 model so that an accurate picture of the behavior of pollutants in this particularly crowded section of the I-80 corridor could be characterized for any given day or traffic volume.

A second, and perhaps more useful type of study could be undertaken using a 24-hour tester to produce accurate measurements of carbon monoxide levels outside of the CO season (December through early January). CALINE4 could then be refined to match the site so that adverse air quality impacts for proposed projects or mitigations in a given site could be more accurately assessed by the model.

Lastly, the CALINE4 model could be used in the same fashion as described in this paper, with or without a sampling program, to estimate the particulate and nitrogen oxides concentrations in the Park.

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Appendices

Appendix A

The percent fuel use refers to the number of vehicles in a certain category using a given fuel. The model takes into account unleaded, leaded and diesel fuel. The year 1990 estimates contained in the model listed the automobile category as more than 90% unleaded. As this estimate seems high in an era when the National Fuel Efficiency Standards on which these assumptions are based have not changed much since 1985, this study chose the 1985 fuel mix data, which uses a lower number for the unleaded automobile category (80%).

Appendix B

The method used by CalTrans employs a 24-hour bag sampler and a computer program called OBSMAX. The OBSMAX program is designed to produce an estimate of the seasonal maximum concentration of carbon monoxide according to a large data base of both meteorological data and recorded carbon monoxide concentrations from California recording stations. This would be a far better way to estimate the carbon monoxide concentration in the Park and would give a much better check on the assumptions made in the CALINE4 model. Due to the unavailability of the bag sampler, this method was not used, although the OBSMAX program was investigated.

Appendix C

The dosimeter was set to the following:

Exchange Rate: dB   Criterion: 90 dB   Range: 50 dB

Calibration level: 110 dB

Appendix D

The computer programs used in this study were acquired from the California Air Resources, Board which discovered some bugs in the programs in the Air Quality Two package of programs and particularly in EMFAC7PC. The version contained in the Air Quality Two package was not endorsed by CARB as it delivered values that were <u>too low</u>. CARB estimated the corrections to the EMFAC7PC version as +8 % for 1987 data and +16% for year 2000 estimations. Since this study chose to use the 1985 estimation year, the correction figures were not included in the results. With this in mind the data in this paper are probably on the low side.